[0035] Fig. 13 is front elevational view of a ring-shaped intracorneal lens with a portion having a cross-section area larger than another portion;

[0036] Fig. 14 is a side cross-sectional view of the lens of Fig. 13, taken along line 14-14;

[0037] Fig. 15 is front elevational view of a ring-shaped intracorneal lens with a portion of the ring ablated or removed;

[0038] Fig. 16 is a side cross-sectional view of the lens of Fig. 15, taken along line 16-16;

[0039] Fig. 17 is a side cross-sectional view of a second embodiment of the present invention, wherein a portion of the intracorneal lens that is offset from the optical axis is ablated by a laser;

[0040] Fig. 18 is a side cross-sectional view of a third embodiment of the present invention, wherein the outer periphery of the intracorneal lens is ablated by a laser;

[0041] Fig. 19 is a side cross-sectional view of the corneal flap repositioned over the intracorneal lens of Fig. 16;

[0042] Fig. 20 is a side cross-sectional view of the corneal flap repositioned over the intracorneal lens of Fig. 17

[0043] Fig. 21 is a side cross-sectional view of the corneal flap repositioned over the intracorneal lens of Fig. 18;

[0044] Fig. 22 is a side cross-sectional view of a compression device compressing the repositioned corneal flap of Fig. 19, to smooth any wrinkles or folds in the flap;

[0045] Fig. 23 is a side cross-sectional view of a therapeutic contact covering the repositioned corneal flap of Fig. 22;

[0046] Fig. 24 is front elevational view of the external surface of the cornea with a mark in the shape of a "plus" aligned with the optical axis; and

[0047] Fig. 25 is front elevational view of the external surface of the cornea with a mark in the shape of a dot aligned with the optical axis.

Detailed Description of the Invention

[0048] Fig. 1 illustrates an example of an integrated system for correcting the refractive error of an eye according an embodiment of the present invention. The system 5 includes device 10 that has at least a first robotic arm or automated device 12, a second robotic arm or automated device 14 and a third robotic arm or automated device 16 coupled thereto. First robotic arm 12 has an ultrashort pulse laser 18 coupled thereto, second robotic arm 14 has an excimer laser 20 coupled thereto and third robotic arm 16 has a lens dispenser 22 coupled thereto. Each device and each robotic arm can be controlled remotely at station 24.

[0049] Device 10 preferably is electrically connected to station 24 using electrical cables 26 or any other manner known in the art. Furthermore, device 10 has a top portion 28 and a support structure 30. Device 10 is capable of moving in any direction desired using wheels (not shown) or any other suitable moving means, such as a track that would allow it to move as desired. Top portion 28 can rotate relative to structure 30, thus allowing device 10 to position itself or the individual robotic arms in any of a variety of ways.

[0050] Station 24 preferably is a movable computer control device that has a monitor 32 and controls 34. Controls 34 allow the surgeon to move and position the device 10 and each individual robotic arm to the proper location for use in the desired surgical technique. Monitor 32 provides the surgeon with a detailed view of the area, which is the subject of the specific surgical step, to achieve this display, each robotic arm preferably has a small camera (not shown), which allows the monitor 32 of the station 24 to display project the specific area that is the subject of the specific surgical step.

[0051] As shown in Figs. 2, 3 and 4, each robotic arm 12, 14 and 16 is substantially similar and therefore, only arm 12 will be described herein. Arm 12 is coupled to top portion 28 by a rotatable joint 36, which allows upper portion 38 of arm 12 rotate 360 degrees relative to top portion 28. Additionally, arm 12 has a shoulder joint 40, which connects the upper portion 38 to arm portion 42 and an elbow joint 44, which connects arm portion 42 with lower arm portion 46. Both joints

40 and 44 can move about at least 180 degrees or more, as desired. Furthermore, arm 12 has a first wrist joint 46 and a second wrist joint 47. First wrist joint 47 allows end portion 50 to rotate 360 degrees and second wrist joint 49 allows the end portion 50 to move about 180 degrees or more, as desired, relative to lower arm portion 46. Laser 18 is coupled to end portion 50 in any conventional manner as desired. By having a variety of joints and arm portions as described above, the arm 12 can move in a similar fashion to a human arm and is not limited to a specific area in which a patient must be positioned to perform the apparatus which will now be described.

[0052] To begin, the refractive error in the eye is measured using wavefront technology, as is known to one of ordinary skill in the art. A more complete description of wavefront technology is set forth in U.S. Patent No. 6,086,204 to Magnate, the entire contents of which is incorporated herein by reference. The refractive error measurements are transmitted to a computerized lathe (not shown) or other lens-shaping machine, where the shape of ocular material used to form the blank or corneal implant is determined based on the information from the wavefront device. Alternatively, the ocular material 52 can be manufactured or shaped prior to the use of the wavefront technology and can be stored in a sterilized manner until that specific shape or size is needed.

[0053] As shown specifically in Fig. 5, a laser 18 is aimed at the surface 54 of the cornea 56 of the eye 58 and energized under the control of station 24 and robotic arm 12. The laser preferably separates the internal area of the cornea into first internal surface 60 and second internal surface 62, which are both substantially circular and form the substantially circular corneal flap 64. First internal surface 60 faces in a posterior direction of cornea 56 and the second internal surface 62 faces in an anterior direction of the cornea 56. The flap 64 preferably has a uniform thickness of about 10-250 microns, and more preferably about 80-100 microns, but can have any suitable thickness. A portion 66 of flap 64 preferably remains attached to the cornea by an area located at the perimeter 68 of flap 64, as shown in Figs. 6 and 7. However, the laser 18 can form a flap of any suitable configuration, such a flap attached at portion surrounding the main optical axis 70 or any other suitable location or a flap that is not